Translation of relevant portions of D3 (JP 09-205272A)

Paragraphs 0012 to 0018

[0012]

[Means for solving the problem and action thereof]

The present process is characterized by comprising contacting a surface of a workpiece with a treatment gas containing a halogen or a hydrogen halide to treat the surface of the workpiece. Exemplary halogens and hydrogen halides include fluorine F_2 and hydrogen fluoride HF.

[0013]

In the present invention, a surface of a workpiece can be treated by chemical reaction using a treatment gas containing a highly-reactive halogen or hydrogen halide, without using an active species having a short lifetime such as fluorine radicals. Furthermore, since a workpiece is not exposed to plasma, no defect due to plasma damage would occur in the workpiece.

[0014]

In the present process, it is preferable to decompose a halogen compound by one of or a combination of pyrolysis, photolysis, decomposition by discharge, and electrolysis to produce the treatment gas. Thus, the present apparatus includes a treatment gas producing means for decomposing a halogen compound by any of the above processes to produce the treatment gas, and a treatment gas supplying means for guiding the treatment gas to a surface of a workpiece.

[0015]

A halogen or hydrogen halide is highly reactive and corrosive. Thus, a stable halogen compound is used as a source material, and is decomposed by any of the above processes to produce the treatment gas. Unlike an active species, the lifetime of a halogen or hydrogen halide is not short.

Therefore, there is no restriction on a length of time required for a halogen or hydrogen halide to reach the workpiece after the decomposition. This increases the degree of freedom in the determination of an area where a workpiece is to be treated.

[0016]

Since organic halogen compounds are neutral, use of an organic halogen compound as a source halogen compound makes it easy to handle.

[0017]

It is preferable to use any of NF_3, SF_6, CF_4 and NH_4F as a halogen compound suitable for the pyrolysis, photolysis and decomposition by discharge. These halogen compounds are used as a source gas, and are supplied to the treatment gas producing means via the source gas supplying means.

[0018]

In the case of decomposing a halogen compound by discharge, it is preferable to decompose a source gas by excitation of the source gas by the pair of electrodes, to which an alternating voltage or a direct voltage of a low frequency of 50 kHz or lower is applied, under atmospheric pressure or pressure close to atmospheric pressure. Thus, the treatment gas producing means of the present apparatus comprises a power supply which outputs an alternating voltage or a direct voltage of a low frequency of 50 kHz or lower, and a plasma generator which includes the pair of electrodes to which the voltage is applied, and induces plasma at atmospheric pressure or pressure close to atmospheric pressure.

Paragraphs 0030 to 0037

[0030] <Process for the preparation of treatment gas>

In the present invention, the treatment gas containing a halogen such as F_2, Cl_2, Br_2 and I_2 or a hydrogen halide such as HF, HCl, HBr and HI is contacted with a workpiece to be treated with the treatment gas so that a surface of the workpiece is treated with the highly-reactive treatment gas. To prepare such a highly-reactive treatment gas, one of the five processes illustrated in Figures 1-5 is employed.

[0031]

In Figures 1-5, a vessel 1 for producing the treatment gas and a treatment gas supply duct 2 for guiding the produced treatment gas to a workpiece are included as common components.

[0032]

In Figure 1, there are included a source gas supply duct 3 for supplying to the vessel 1 a halogen compound used as the source gas, e.g., NF_3, and a heater 4 for heating the inside of the vessel 1. In Figure 1, the halogen compound is pyrolyzed using heat energy in the vessel 1 to produce the treatment gas containing a halogen or hydrogen halide.

[0033]

In the case of using NF_3 as the source gas, a temperature of 300°C or higher is required to pyrolyze NF_3. In the present Example, when NF_3 was heated at 500°C, a treatment gas containing about 1000 ppm of fluorine F_2 was produced by the pyrolysis $2NF_3 \rightarrow N_2 + 3F_2$.

[0034]

In the embodiment illustrated in Figure 2, a halogen compound used as the source gas is photolyzed to produce a treatment gas in the vessel 1 connected to the supply duct 2 and a source gas supply duct 3. Thus, a UV lamp 5 for radiation of light such as ultraviolet light is provided in

the vessel 1.

[0035]

NF_3 was used as the source gas, and when a lamp output of the UV lamp 5 was set to 100 mW/cm^2 and a wavelength of light to be emitted was set to 400 nm, the photolysis of the reaction formula specified above in the case of Figure 1 occurred to produce a treatment gas containing about 100 ppm of fluorine F_2.

[0036]

In the embodiment illustrated in Figure 3, a halogen compound used as the source gas is decomposed by discharge at atmospheric pressure or pressure close to atmospheric pressure to produce a treatment gas in the vessel 1 connected to the supply duct 2 and a source gas supply duct 3. Thus, a plasma generator 6 including a pair of electrodes is provided in the vessel 1.

[0037]

The source gas CF_4 was supplied at 100 cc/min using the apparatus shown in Figure 3, and the power supply frequency to be supplied to the pair of electrodes was set to about 10 kHz. The discharge was carried out with a peak-to-peak voltage of a discharge voltage of AC10kVpp. At this time, the source gas was decomposed such that $2CF_4 \rightarrow C_2F_6 + F_2$ to produce a treatment gas containing about 800 ppm of fluorine F_2.

Paragraphs 0056 to 0060

[0056] Process for the surface treatment using the surface treatment unit shown in Figure 7

In Embodiment 1, compressed air is used as a carrier gas, and a halogen compound such as CF_4 is used as a source gas. The carrier gas and the source gas are introduced into a carrier gas supply duct 90 and a source gas supply duct 41 of a surface treatment unit 30, respectively, by use of facilities provided in a factory. The flow rates of the source gas and the carrier gas are regulated by flow meters 42 and 92 provided to middle parts of the supply ducts 41 and 90, respectively. In the present Embodiment, the flow rate of the carrier gas, i.e., compressed air, is 20 L/min, and the flow rate of the source gas, i.e., CF_4, is 50 cc/min. Accordingly, the concentration of the source gas with respect to the carrier gas is $(50\ \text{cc}/20\ \text{L}) \times 100 = 0.25\%$ by volume. The concentration of the source gas may be lower than 0.5% by volume, i.e., lower than 100 cc/min.

[0057]

In the present Embodiment, only the source gas CF_4 with a regulated flow rate is introduced into a plasma generator 60. To a pair of electrodes 62a and 62b provided in the plasma generator 60, an alternating voltage of a relatively low frequency of 10-50 kHz is applied. Thus, even when the amount of the source gas CF_4 is small, and even when He gas, which facilitates plasma generation, is not present in a large amount, the period of an alternating voltage is long, enabling stable plasma generation under atmospheric pressure or pressure close to atmospheric pressure.

[0058]

In the plasma generator 60, the source gas CF_4 is excited and decomposed to produce fluorine F_2, which is a highly-reactive halogen. The carrier

gas supply duct 90 is connected to a treatment gas supply duct 40 provided at a downstream side of the plasma generator 60, and the carrier gas flowing at a relatively high flow rate of 20 L/min is mixed with the produced treatment gas so that the treatment gas is pressure transported by the carrier gas.

[0059]

The treatment gas and the carrier gas discharged from the supply duct 40 of the surface treatment unit 30 are then exposed on a surface of an IC 10 by a supply section 22 via a gas supply connecting duct 20 connected to the unit 30. Consequently, a surface of a lead frame 12 of the IC 10 is treated as shown by the following chemical formula

[0060]

$$2SnO+2F_2 \rightarrow 2SnF_2+O_2.$$

In the chemical formula, SnO is an oxide present on the surface of the lead frame 12, and is converted into a halogen compound (SnF_2) when contacting with the treatment gas. Further, since the IC 10, which is a work, is not exposed to plasma, the IC 10 would not be damaged.